FEDERAL GLOSSARY OF SELECTED TERMS
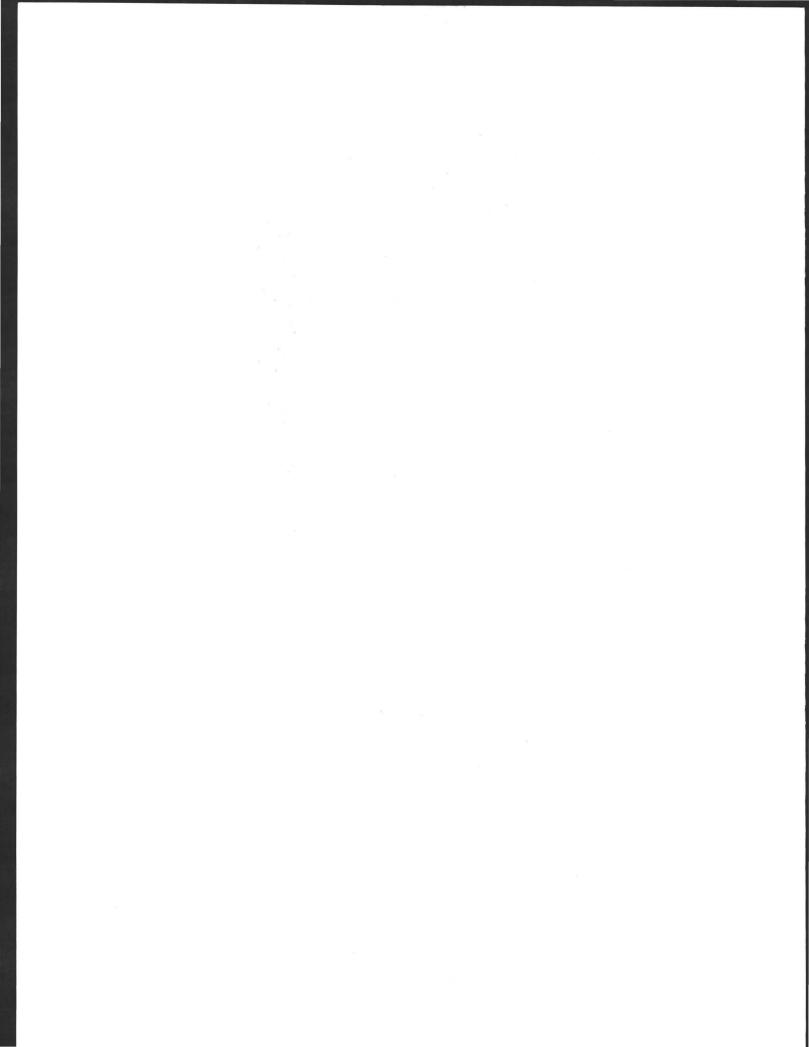
Subsurface-Water Flow and Solute Transport

Ground Water Subcommittee of the
Federal Interagency Advisory Committee
on Water Data

August 1989

Department of the Interior
U.S. Geological Survey
Office of Water Data Coordination

SUBSURFACE-WATER FLOW AND SOLUTE TRANSPORT

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Prepared by the
Subsurface-Water Glossary Working Group
Ground-Water Subcommittee
Interagency Advisory Committee on Water Data

Department of the Interior
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FOREWORD

The purpose of this report is to provide a glossary of selected terms for saturated and unsaturated flow and related processes involved in transport of contaminants in the subsurface. The glossary contains five tables. Table 1 is a list of parameters with associated symbols and units. Tables 2 to 5 are conversion charts. The original manuscript was prepared by Thomas J. Nicholson, U.S. Nuclear Regulatory Commission. It was subsequently examined by the Ground-Water Glossary Working Group and experts within and outside the Federal Government, whose recommendations were accommodated where appropriate in the glossary. It is hoped that the glossary will aid in the communications between soil scientists, hydrologists, and hydrogeologists.

The terms defined in the glossary were selected after an extensive survey of glossaries and reports in the areas of (1) ground-water geology, hydraulics, and chemistry, (2) soil-water physics and chemistry, (3) contaminant transport, (4) unsaturated-zone hydrology, (5) chemistry and transport of solutes, and (6) ground-water quality. Some of the definitions have been modified for clarity from a variety of technical sources. Where more than one definition appears for the selected term, the first one was determined by the working group to be the most appropriate general definition, followed by other, more specialized, definitions. Some terms and definitions are not currently in use by all agencies; however, they are included in the glossary because they can be found in the literature. The reader is encouraged to consult with the original source cited for more explanatory comments. Additional regulatory definitions, which are underlined and are taken directly from the Code of Federal Regulations (CFR) and Federal laws (USC), were added following review by the various Federal agencies in May 1986.

The definitions and conversion charts are from two principal sources provided herein. The first is the "Glossary" compiled by A. I. Johnson in the 1981 report by the American Society of Testing and Materials titled Permeability and Groundwater Contaminant Transport. The second is Manual 40, "Ground-water Management," produced by the American Society of Civil Engineers in 1985.

It is anticipated that the glossary will be updated on a periodic basis. Review comments and suggestions concerning the glossary are desired and should be addressed to:

    Office of Water Data Coordination
    U.S. Geological Survey
    417 National Center
    Reston, Virginia 22092

Comments on definitions should include specific wording and citations, if available. Suggestions received by the Office of Water Data Coordination will be forwarded to the Ground-Water Subcommittee for their consideration. Changes approved by the Ground-Water Subcommittee will be submitted to the Interagency Advisory Committee on Water Data for their approval.

DEFINITIONS

absorption - the process by which substances in gaseous, liquid or solid form dissolve or mix with other substances (ASCE, 1985).

adsorption - adherence of gas molecules, ions, or molecules in solution to the surface of solids (ASCE, 1985).

adsorption isotherm - a graphical representation of the relationship between the bulk activity of adsorbate and the amount adsorbed at constant temperature (after Stumm and Morgan, 1981).

advection - the process whereby solutes are transported by the bulk mass of flowing fluid (Freeze and Cherry, 1979).
    See also convective transport.

air-space-ratio, (D)* - the ratio of (a) the volume of water that can be drained from a saturated soil or rock under the action of force of gravity to (b) the total volume of voids (ASTM, 1980).

anisotropy - the condition of having different properties in different directions (AGI, 1980).

anisotropic mass - a mass having different properties in different directions at any given point (ASTM, 1980).

apparent ground-water velocity - see specific discharge.

aquiclude - a hydrogeologic unit which, although porous and capable of storing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring (after WMO, 1974).
    See preferred term confining unit.

aquifer -

(1) a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (after Lohman and others, 1972).

(2) means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs. Any saturated zone created by uranium or thorium recovery operations would not be considered an aquifer unless the zone is or potentially is (1) hydraulically interconnected to a natural aquifer, (2) capable of discharge to surface water, or (3) reasonably accessible because of migration beyond the vertical projection of the boundary of the land transferred for long-term government ownership and care (10 CFR Part 40 Appendix A).

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*The abbreviations in parentheses stand for terms of measurement and are defined as follows: D = dimensionless; L = length; T = time; and M = mass

(3) means a formation, a group of formations, or a part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (10 CFR Part 960.2).

(4) means a zone, stratum, or groups of strata that can store or transmit water in sufficient quantities for a specific use (30 CFR Part 710.5).

(5) a geological formation, groups of formations, or part of a formation, that is capable of yielding a significant amount of water to a well or spring (40 CFR Parts 146.03; 260.10; 270.2).

(6) a geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of ground water to wells or springs (40 CFR Part 257.3-4).

aquifer system - a body of permeable and poorly permeable material that functions regionally as a water-yielding unit; it comprises two or more permeable beds separated at least locally by confining beds that impede ground-water movement but do not greatly affect the regional hydraulic continuity of the system; includes both saturated and unsaturated parts of permeable material (after ASCE, 1985).

aquifer test - a test to determine hydrologic properties of the aquifer involving the withdrawal of measured quantities of water from or addition of water to a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or additions (ASCE, 1985).

aquifuge -

(1) a hydrogeologic unit which has no interconnected openings and, hence cannot store or transmit water (after WMO, 1974).

(2) a rock which contains no interconnected openings or interstices and therefore neither stores nor transmits water (ASCE, 1985).

(3) an impermeable rock (ASCE, 1985).
    See preferred term confining unit.

aquitard - a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed. It does not readily yield water to wells or springs, but may serve as a storage unit for ground water (AGI, 1980).
    See preferred term confining unit.

area of influence of a well - the area surrounding a pumping or recharging well within which the potentiometric surface has been changed (after ASCE, 1985).

artesian - synonymous with confined (Lohman and others, 1972).

artesian aquifer - synonymous with confined aquifer (ASCE, 1985).

artesian well - a well deriving its water from an artesian or confined aquifer (after ASCE, 1985).

artificial recharge - recharge at a rate greater than natural, resulting from deliberate or incidental human activities (WRC, 1980).

average interstitial velocity - see velocity, average interstitial.

base flow - that part of the stream discharge that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by ground-water discharge (after APHA, 1981).

baseline monitoring - the establishment and operation of a designed surveillance system for continuous or periodic measurements and recording of existing and changing conditions that will be compared with future observations (after NRC, 1982).

breakthrough curve - a plot of relative concentration versus time, where relative concentration is defined as C/C_0 with C as the concentration at a point in the ground-water flow domain, and C_0 as the source concentration.

buildup, (L) - the vertical distance the water table or potentimetric surface is raised, or the increase of the pressure head due to the addition of water.

capillary action - the movement of water in the interstices of a porous medium due to capillary forces (after ASTM, 1980).
     Synonymous with capillarity, capillary flow, and capillary migration.

capillary conductivity -

    (1)   the property of an unsaturated porous medium to transmit liquid (after AGI, 1980).

    (2)   coefficient which expresses the extent to which an unsaturated permeable medium allows flow of water through its interstices, under a unit gradient of capillary potential (after WMO, 1974).

capillary fringe - the lower subdivision of the unsaturated zone immediately above the water table in which the interstices are filled with water under pressure less than that of the atmosphere, being continuous with the water below the water table but held above it by capillary forces (after ASCE, 1985).

capillary head, (L) - the potential, expressed in head of water, that causes the water to flow by capillary action (ASTM, 1980).

capillary migration - see capillary action.

capillary potential, $(ML^{-1}T^{-2})$ - the scalar quantity that represents the work required to move a unit mass of water from the soil to a chosen reference location and energy state (after SSSA, 1975).

capillary pressure, $(ML^{-1}T^{-2})$ - the difference in pressure across the interface between two immiscible fluid phases jointly occupying the interstices of a porous medium caused by interfacial tension between the two phases (after AGI, 1980).

capillary rise (height of capillary rise), (L) - the height above a free water surface to which water will rise by capillary action (ASTM, 1980).
    Synonymous with height of capillary rise.

capillary water -

    (1)   water held in the soil above the phreatic surface by capillary forces.

    (2)   soil water above hydroscopic moisture and below the field capacity (WMO, 1974).

cascading water - in reference to wells, ground water which trickles or pours through cracks or perforations down the casing or uncased borehole above the water level in the well (after Wilson, 1980).

cation exchange capacity, $(mol(+)M^{-1})$ - the sum total of exchangeable cations that a porous medium can absorb. Expressed in moles of ion charge per kilogram of soil (or of other exchanges such as clay) (after SSSA, 1975).

centrifuge moisture equivalent - see moisture equivalent.

concentration gradient - the change in solute concentration per unit distance in solute. Concentration gradients cause Fickian diffusion (spreading) of solutes from regions of highest to regions of lowest concentrations. In slow moving ground water, this is the dominant mixing process.

cone of depression - a depression of the potentiometric surface in the shape of an inverted cone that develops around a well which is being pumped (after ASCE, 1985).

cone of impression - a rise of the potentiometric surface in the shape of a cone that develops around an injection well.

confined - a modifier which describes a condition in which the potentiometric surface is above the top of the aquifer.
    Synonymous with artesian.

confined aquifer -

    (1)   an aquifer bounded above and below by confining units of distinctly lower permeability than that of the aquifer itself (ASCE, 1985).

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(2) an aquifer containing confined ground water (ASCE, 1985).

(3) an aquifer bounded above and below by impermeable beds or by beds of distinctly lower permeability than that of the aquifer itself; an aquifer containing confined ground water (40 CFR 260.10).

confining bed -

(1) see confining unit.

(2) a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers (40 CFR 146.3).

confining unit -

(1) a hydrogeologic unit of impermeable or distinctly less permeable material bounding one or more aquifers and is a general term that replaces aquitard, aquifuge, aquiclude (after AGI, 1980).
    See definition 2, confining bed.

(2) means a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers (10 CFR Part 960.2).

confining zone -

(1) see confining unit.

(2) a geological formation, group of formations, or part of a formation that is capable of limiting fluid movement above an injection zone (40 CFR 146.3).

connate water - water entrapped in the interstices of a sedimentary or extrusive igneous rock at the time of its deposition (AGI, 1980).

contaminant -

(1) an undesirable substance not normally present or an unusually high concentration of a naturally occurring substance in water or soil.

(2) see pollutant.

(3) any physical, chemical, biological, or radiological substance or matter in water (40 CFR 142.2; 40 CFR 149.2; 40 CFR 141.2; 40 CFR 143.2; 40 CFR 146.3).

contamination - the addition to water of any substance or property preventing the use or reducing the usability of the water (AGI, 1980).
    Sometimes considered synonymous with pollution.

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contaminant plume - an elongated body of ground water containing contaminants, emanating and migrating from a point source within a hydrogeologic unit(s).

contaminate - <u>introduce a substance that would cause:</u>

(1) <u>the concentration of that substance in the ground water to exceed the maximum contaminant levels, or</u>

(2) <u>an increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the maximum contaminant levels</u> (40 CFR 257.3-4).
   See pollutant.

convective diffusion - see mechanical dispersion, coefficient.

convective transport - the component of movement of heat or mass induced by thermal gradients in ground water.
   See also advection.

convection - the process whereby heat is carried along with the flowing ground water (after Freeze and Cherry, 1979).

Darcian velocity - see specific discharge.

Darcy's law - an empirical law which states that the velocity of flow through a porous medium is directly proportional to the hydraulic gradient assuming that the flow is laminar and inertia can be neglected (after Darcy, 1856).

deep percolation - the drainage of soil water downward by gravity below the maximum effective depth of the root zone toward storage in subsurface strata (ASCE, 1985).

degree of saturation - see percent saturation.

desorption - the reverse process of sorption.
   See also sorption.

discharge area - an area in which ground water is discharged to the land surface, surface water, or atmosphere (WRC, 1980).

differential water capacity - the absolute value of the rate of change of water content with soil water pressure. The water capacity at a given water content will depend on the particular desorption or adsorption curve employed. Distinction should be made between volumetric and specific water capacity (SSSA, 1975).

diffusion - process whereby ionic or molecular constituents move under the influence of their kinetic activity in the direction of their concentration gradient (Freeze and Cherry, 1979).

diffusion coefficient - see molecular diffusion, coefficient.

diffusion, convective - see mechanical dispersion, coefficient.

diffusivity, soil water, ($L^2 T^{-1}$) - the hydraulic conductivity divided by the differential water capacity (care being taken to be consistent with units), or the flux of water per unit gradient of moisture content in the absence of other force fields (SSSA, 1975).

diffusivity, hydraulic, ($L^2 T^{-1}$) - the ratio of transmissivity divided by the storage coefficient or the hydraulic conductivity divided by the specific storage (Lohman and others, 1972).

dispersion coefficient, ($L^2 T^{-1}$) -

   (1)   a measure of the spreading of a flowing substance due to the nature of the porous medium, with its interconnected channels distributed at random in all directions (ANS, 1980).

   (2)   the sum of the coefficients of mechanical dispersion and molecular diffusion in a porous medium (Bear, 1979).

dispersion, longitudinal - process whereby some of the water molecules and solute molecules travel more rapidly than the average linear velocity and some travel more slowly; spreading of the solute in the direction of the bulk flow (after Freeze and Cherry, 1979).

dispersion, mechanical - see mechanical dispersion.

dispersion, transverse - spreading of the solute in directions perpendicular to the bulk flow (after Freeze and Cherry, 1979).

dispersivity, (L) - a geometric property of a porous medium which determines the dispersion characteristics of the medium by relating the components of pore velocity to the dispersion coefficient (ANS, 1980).

disposal well -

   (1)   see injection well.

   (2)   a well used for the disposal of waste into a subsurface stratum (40 CFR 146.3).

distribution coefficient, ($L^3 M^{-1}$) - the quantity of the solute, chemical or radionuclide sorbed by the solid per unit weight of solid divided by the quantity dissolved in the water per unit volume of water (ANS, 1980).

drainage well -

   (1)   a well installed to drain surface water, storm water, or treated waste water into underground strata (after ASCE, 1985).

(2)   a water well constructed to remove subsurface water or to reduce a
       hydrogeologic unit's potentiometric surface (after ASCE, 1985).

drawdown, (L) -

(1)   the vertical distance the water elevation is lowered or the
       reduction of the pressure head due to the removal of water (after
       ASCE, 1985).

(2)   the decline in potentiometric surface at a point caused by the
       withdrawal of water from a hydrogeologic unit (after Heath, 1984).

effective hydraulic conductivity - see hydraulic conductivity, effective.

effective porosity, (D) - see porosity, effective.

effluent stream - see gaining stream.

electrical conductivity - measure of the ability of material to conduct an
     electrical current. For water samples, it depends on the concentration
     and type of ionic constituents in the water and temperature of the
     water; and it is expressed in siemens per meter.

equipotential line (or surface) - line (or surface) along which the potential
     is constant (WMO, 1974).

evapotranspiration - the combined loss of water from a given area by evapo-
     ration from the land and transpiration from plants (after SSSA, 1975).

exchange capacity, $(mol(+) M^{-1})$ -

(1)   the amount of exchangeable ions measured in moles of ion change per
       kilogram of solid material at a given pH (after ANS, 1980).
       Synonymous with ion exchange capacity.

(2)   the total ionic charge of the adsorption complex active in the
       adsorption of ions (SSSA, 1975).
       See also cation-exchange capacity.

Fickian diffusion - spreading of solutes from regions of highest to regions of
     lower concentrations caused by the concentration gradient. In slow
     moving ground water, this is the dominant mixing process (after Freeze
     and Cherry, 1979).

field capacity (field moisture capacity) - see specific retention.

flow line - the general path that a particle of water follows under laminar
     flow conditions (after ASTM, 1980).

flow net - a graphical representation of flow lines and equipotential lines
     for two-dimensional, steady-state ground-water flow (after ASTM, 1980).

flow path - the subsurface course a water molecule or solute would follow in a given ground-water velocity field.

flow, steady - a characteristic of a flow system where the magnitude and direction of specific discharge are constant in time at any point
See also flow, unsteady.

flow, uniform - a characteristic of a flow system where specific discharge has the same magnitude and direction at any point.

flow, unsteady - a characteristic of a flow system where the magnitude and/or direction of the specific discharge changes with time.
Synonymous with nonsteady flow. See also flow, steady.

flow velocity - see specific discharge.

fluid potential, ($L^2 T^{-2}$) - the mechanical energy per unit mass of a fluid at any given point in space and time with regard to an arbitrary state and datum (Lohman and others, 1972).

flux - see specific discharge.

formation fluid - "fluid" present in a "formation" under natural conditions as opposed to introduced fluids, such as drilling mud (40 CFR 146.3).

free water - see gravitational water.

free water elevation - see water table.

fresh water - water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; generally more than 500 mg/L is undesirable for drinking and many industrial uses (USGS, 1984). See also saline water.

gaining stream - a stream or reach of a stream whose flow is being increased by inflow of ground water (ASCE, 1985).

geohydrologic system -

(1) see ground-water system.

(2) the geohydrologic units within a geologic setting, including any recharge, discharge, interconnections between units, and any natural or human-induced processes or events that could affect ground-water flow within or among those units (10 CFR Part 960.2).

geohydrologic unit -

(1) see hydrogeologic unit.

(2) an aquifer, a confining unit, or a combination of aquifers and confining units comprising a framework for a reasonably distinct geohydrogeologic system (10 CFR Part 960.2).

gravitational head, (L) - the component of total hydraulic head related to the position of a given mass of water relative to an arbitrary datum (Wilson, 1980).

gravitational water - water which moves into, through, or out of the soil or rock mass under the influence of gravity (SSSA, 1975).

ground water -

(1) that part of the subsurface water that is in the saturated zone.

(2) loosely, all subsurface water as distinct from surface water (ASCE,1985).

(3) all water which occurs below the land surface. It includes both water within the unsaturated and saturated zones (NRC, 1985).

(4) means water below the land surface in a zone of saturation. For purpose of this appendix, ground water is the water contained within an aquifer (10 CFR Part 40 Appendix A).

(5) all water which occurs below the land surface (10 CFR Part 60.2).

(6) all subsurface water as distinct from surface water (10 CFR Part 960).

(7) subsurface water that fills available openings in rock or soil materials to the extent that they are considered water-saturated (30 CFR Part 710.5 and 710.5).

(8) water below the land surface in a zone of saturation (40 CFR 270.2; 40 CFR 146.3; 40 CFR 144.3).

(9) water in a saturated zone or stratum beneath the surface of land or water (40 CFR 300.6; 40 CFR 257.3-4).

ground-water barrier - rock or artificial material which has a relatively low permeability and which occurs below the land surface where it impedes the movement of ground water and consequently causes a pronounced difference in the potentiometric surface on opposite sides of it (after ASCE, 1985).

ground-water basin - a general term used to define a ground-water flow system that has defined boundaries and may include permeable materials that are capable of storing or furnishing a significant water supply, the basin includes both the surface area and the permeable materials beneath it (after ASCE, 1985).

ground water, confined - ground water under pressure significantly greater than atmospheric and whose upper limit is the bottom of a confining unit (after Lohman and others, 1972).
See also confined, confining unit, and confined aquifer.

ground-water discharge, ($L^3 T^{-1}$) -

(1) flow of water from the zone of saturation;

(2) the water released from the zone of saturation;

(3) the quantity of water released (ASCE, 1985).

ground-water divide - a ridge in the water table or other potentiometric surface from which ground water moves away in both directions normal to the ridge line (WRC, 1980).

ground-water flow - the movement of water in the zone of saturation.

ground-water flux -

(1) see specific discharge.

(2) the rate of ground-water flow per unit area of porous or fractured media measured perpendicular to the direction of flow (10 CFR Part 960.2).

ground-water mound - a raised area in a water table or other potentiometric surface created by ground-water recharge.

ground water, perched -

(1) see perched ground water.

(2) unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table. Perched ground water is held up by a perching bed whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure (10 CFR Part 960.2).

ground-water recharge - the process of water addition to the saturated zone or the volume of water added by this process (ANS, 1980).

ground-water system - a ground-water reservoir and its contained water. Also, the collective hydrodynamical and geochemical processes at work in the reservoir (USGS, 1984).

ground-water travel time -

(1) the time required for ground water to travel between two locations.

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(2) the time required for a unit volume of ground water to travel
     between two locations. The travel time is the length of the flow
     path divided by the velocity, where velocity is the average ground-
     water flux passing through the cross-sectional area of the geologic
     medium through which flow occurs, perpendicular to the flow
     direction, divided by the effective porosity along the flow path.
     If discrete segments of the flow path have different hydrologic
     properties the total travel time will be the sum of the travel times
     for each discrete segment (10 CFR Part 960.2).

ground water, unconfined - water in an aquifer that has a water table
     (Lohman and others, 1972).
          Synonymous with phreatic ground water.

head, static, (L) - the height above a standard datum of the surface of a
     column of water (or other liquid) that can be supported by the static
     pressure at a given point. The static head is the sum of the elevation
     head and the pressure head (after Lohman and others, 1972).

head, total, (L) - the total head of a liquid at a given point is the sum of
     three components: (a) the elevation head, which is equal to the
     elevation of the point above a datum, (b) the pressure head, which is the
     height of a column of static water that can be supported by the static
     pressure at the point, and (c) the velocity head, which is the height to
     which the kinetic energy of the liquid is capable of lifting the liquid
     (Lohman and others, 1972).

heterogeneity - a characteristic of a medium in which material properties vary
     from point to point (after ANS, 1980).

homogeneity - a characteristic of a medium in which material properties are
     identical everywhere (see Lohman and others, 1972).

hydraulic barrier - a general term referring to modifications of a ground-
     water flow system to restrict or impede movement of contaminants.

hydraulic conductivity, $(L\ T^{-1})$ -

     (1) a proportionality constant relating hydraulic gradient to specific
          discharge which for an isotropic medium and homogeneous fluid,
          equals the volume of water at the existing kinematic viscosity that
          will move in unit time under a unit hydraulic gradient through a
          unit area measured at right angles to the direction of flow (after
          ASCE, 1985).

     (2) the volume of water that will move through a medium in a unit of
          time under a unit hydraulic gradient through a unit area measured
          perpendicular to the direction of flow (10 CFR Part 960.2).

hydraulic conductivity, effective, $(L\ T^{-1})$ - the rate of flow of water through
     a porous medium that contains more than one fluid, such as water and air
     in the unsaturated zone, and which should be specified in terms of both

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the fluid type and content and the existing pressure (Lohman and others, 1972).

hydraulic diffusivity, ($L^2 T^{-1}$) - see diffusivity, hydraulic.

hydraulic dispersion - see mechanical dispersion.

hydraulic gradient, (D) -

   (1) the change in static head per unit of distance in a given direction. If not specified, the direction generally is understood to be that of the maximum rate of decrease in head.

   (2) slope of the water table or potentiometric surface (ASCE, 1985).

   (3) a change in the static pressure of ground water, expressed in terms of the height of water above a datum, per unit of distance in a given direction (10 CFR Part 960.2).

hydraulic head, (L) - the height above a datum plane (such as sea level) of the column of water that can be supported by the hydraulic pressure at a given point in a ground water system. For a well, the hydraulic head is equal to the distance between the water level in the well and the datum plane (ASCE, 1985).

hydrochemical facies - distinct zones that have cation and anion concentrations of diagnostic chemical character of water solutions in hydrologic systems which is describable within defined composition categories (after Freeze and Cherry, 1979).

hydrodynamic dispersion - the spreading (at the macroscopic level) of the solute front during transport resulting from both mechanical dispersion and molecular diffusion (Bear, 1979).

hydrodynamic dispersion, coefficient of - see dispersion coefficient.

hydrogeologic unit -

   (1) any soil or rock unit or zone which by virtue of its hydraulic pro- perties has a distinct influence on the storage or movement of ground water (after ANS, 1980).

   (2) means any soil or rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of ground water (10 CFR Part 61.2).

hydrograph - a graph relating stage, flow, velocity, or other characteristics of water with respect to time (after ASCE, 1985).

hydrologic properties - those properties of a rock that govern the entrance of water and the capacity to hold, transmit, and deliver water, such as porosity, effective porosity, specific retention, permeability, and the directions of maximum and minimum permeabilities (10 CFR Part 960.2).

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hydrostratigraphic unit - see hydrogeologic unit.

immiscible -

    (1)   two or more liquids that are not readily soluble (AGI, 1980).

    (2)   the chemical property of two or more phases that, at mutual equili-
brium, cannot dissolve completely in one another, e.g. oil and water
(AGI, 1980).

impermeable - a characteristic of some geologic material that limits its
ability to transmit significant quantities of water under the head
differences ordinarily found in the subsurface (after ASCE, 1985).

infiltration - the downward entry of water into the soil or rock (SSSA, 1975).

infiltration capacity - the maximum rate at which a soil or rock is capable of
absorbing water or limiting infiltration (after ASCE, 1985).

infiltration rate, (LT^{-1}) -

    (1)   the rate at which a soil or rock under specified conditions absorbs
falling rain, melting snow, or surface water expressed in depth of
water per unit time (ASCE, 1985).

    (2)   a characteristic describing the maximum rate at which water can
enter the soil or rock, under specified conditions, including the
presence of an excess of water. It has the dimensions of velocity
(SSSA, 1975).

influent stream - see losing stream.

injection well -

    (1)   well used for emplacing fluids into the subsurface.

    (2)   a well into which fluids are being injected (40 CFR Parts 144.3;
146.3; and 270.2).

injection zone - a geological "formation," group of formations, or part of a
formation receiving fluids through a well (40 CFR Part 146.3).

in-situ density - the density of water measured at its actual depth
(AGI, 1980).
    See potential density.

interface - the contact zone between two materials of different chemical or
physical composition (after USGS, 1984).

interstice -

    (1)   an opening in a rock or soil that is not occupied by solid matter (AGI, 1980).

    (2)   an opening or space which may be occupied by air, water, or other gaseous or liquid material (ASTM, 1980).
        Synonymous with void, pore.

intrinsic permeability - see permeability, intrinsic.

irrigation return flow - the part of artifically applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface water body (USGS, 1984).

isotropic mass - a mass having the same property or properties in all directions (AGI, 1980).

isotropy - the condition in which the property or properties of interest are the same in all directions.

laminar flow - flow in which the head loss is proportional to the first power of the velocity (ASTM, 1980).
    Synonymous with streamline flow, viscous flow.

leachate -

    (1)   materials removed by the process of leaching.

    (2) a liquid that has percolated through soil, rock or waste and has extracted dissolved or suspended materials (30 CFR Part 710.5).

leaching -

    (1)   the removal of materials in solution from soil, rock, or waste (after SSSA, 1975).

    (2)   separation or dissolving out of soluble constituents from a porous medium by percolation of water (McGraw-Hill, 1974).

leakage -

    (1)   the flow of water from one hydrogeologic unit to another. The leakage may be natural, as through semi-impervious confining layer, or human-made, as through an uncased well (APHA, 1981).

    (2)   the natural loss of water from artificial structures as a result of hydrostatic pressure.

leakance, (T^{-1}) -

    (1)   the ratio K'/b' , in which K' and b' are the vertical hydraulic con-
          ductivity and the thickness, respectively, of the confining beds
          (Lohman and others, 1972).

    (2)   the rate of flow across a unit (horizontal) area of a semipervious
          layer into (or out of) an aquifer under one unit of head difference
          across this layer (Bear, 1979).
          Synonymous with coefficient of leakage.

leaky aquifer - aquifers, whether artesian or water-table, that lose or gain
      water through adjacent less permeable layers (after Hantush, 1964).

line of seepage - see seepage line.

losing stream - a stream or reach of a stream in which water flows from the
      stream bed into the ground (ASCE, 1985).
      Synonymous with influent stream.

lysimeter - a device for measuring percolation and leaching losses from a
      column of soil under controlled conditions (SSSA, 1975).

matric potential, (L) - the energy required to extract water from a porous
      medium to overcome the capillary and adsorptive forces (after Wilson,
      1980).

matrix - the solid framework of a porous system (Wilson, 1980).

mechanical dispersion - the process whereby solutes are mechanically mixed
      during advective transport caused by the velocity variations at the
      microscopic level.
      Synonymous with hydraulic dispersion.

mechanical dispersion, coefficient $(L^2\ T^{-1})$ - the component of mass transport
      flux of solutes caused by velocity variations at the microscopic level
      (after Bear, 1979).
      Synonymous with convective diffusion.

miscible -

    (1)   two or more liquids that are mutually soluble (i.e. they will dis-
          solve in each other) (McGraw-Hill, 1974).

    (2)   the chemical property of two or more phases that, when brought
          together, have the ability to mix and form one phase (after AGI,
          1980).

miscible displacement - the mutual mixing and movement of two fluids that are
      soluble in each other (after Freeze and Cherry, 1979).
      Synonymous with miscible-phase displacement.

model -

    (1)   a conceptual, mathematical, or physical system obeying certain specificed conditions, whose behavior is used to understand the physical system to which it is analogous in some way (after McGraw-Hill, 1974).

    (2)   <u>a conceptual description and the associated mathematical representation of a system, subsystem, components, or condition that is used to predict changes from a baseline state as a function of internal and/or external stimuli and as a function of time and space</u> (10 CFR Part 960.2).

moisture content, (D) - the ratio, expressed as a percentage, of either (a) the weight of water to the weight of solid particles expressed as <u>moisture weight percentage</u> or (b) the volume of water to the volume of solid particles expressed as <u>moisture volume percentage</u> in a given volume of porous medium (ASTM, 1980).
    See water content.

moisture equivalent - the percentage of water retained in a soil sample 1 cm thick after it has been saturated and subjected to a centrifugal force 1000 times gravity for 30 minutes (SSSA, 1975). <u>Centrifuge moisture equivalent</u> is the water content of a soil after it has been saturated with water and then subjected for 1 hour to a force equal to 1000 times that of gravity (ASTM, 1980).

moisture tension - the equivalent negative pressure of water in an unsaturated porous medium equal to the pressure that must be applied to the medium to bring the water to hydraulic equilibrium through a porous permeable material with a pool of water of the same composition (after SSSA, 1975).

moisture volume percentage - the ratio of the volume of water in a soil to the total bulk volume of the soil (SSSA, 1975).

moisture weight percentage - the moisture content expressed as a percentage of the oven-dry weight of a soil (SSSA, 1975).

molecular diffusion (diffusion) - the process whereby solutes are transported at the microscopic level due to variations in the solute concentrations within the fluid phases.

molecular diffusion, coefficient of, ($L^2 T^{-1}$) - the component of mass transport flux of solutes (at the microscopic level) due to variations in solute concentrations within the fluid phases (after Bear, 1979).
    Synonymous with diffusion coefficient.

non-point source -

    (1)   any source, other than a point source, which discharges pollutants into air or water (APHA, 1981).

(2)   source orginating over broad areas, such as areas of fertilizer and pesticide application and leaking sewer systems, rather than from discrete points (after USGS, 1988).

particulate transport - the movement of particles in subsurface water.

partitioning function - a mathematical relation describing the distribution of a reactive solute between solution and other phases.

Peclet number, (D) - a relationship between the advective and diffusive components of solute transport expressed as the ratio of the product of the average interstitial velocity, times the characteristic length, divided by the coefficient of molecular diffusion; small values indicate diffusion dominance, large values indicate advection dominance.

percent saturation, (D) - the ratio, expressed as a percentage, of (a) the volume of water to (b) the total volume of intergranular space (voids) in a given porous medium (ASTM, 1980).
      Synonymous with degree of saturation.

perched ground water -

(1)   ground water separated from an underlying body of ground water by an unsaturated zone (ASCE, 1985).

(2)   unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table. Perched ground water is held up by a perching bed whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure (10 CFR Part 960.2).

pellicular water -

(1)   the film of water left around each grain or fracture surface of water-bearing material after gravity drainage (after APHA, 1981).

(2)   water of adhesion; (after APHA, 1981).

(3)   water that can be extracted by root absorption and evaporation but cannot be moved by gravity or by the unbalanced film forces resulting from localized evaporation and transpiration (after APHA, 1981).

percolation -

(1)   the downward movement of water through the unsaturated zone.

(2)   the downward flow of water in saturated or nearly saturated porous medium at hydraulic gradients of the order of 1.0 or less (after SSSA, 1975).

permeability - the property of a porous medium to transmit fluids under an hydraulic gradient.

permeability coefficient, (LT^{-1}) - the rate of flow of water through a unit cross-sectional area under a unit hydraulic gradient at the prevailing temperature (field permeability coefficient) or adjusted to a temperature of $15^{\circ}C$ ($60^{\circ}F$) (ASCE, 1985).

permeability, effective - the observed permeability of a porous medium to one fluid phase under conditions of physical interaction between this phase and other fluid phases present (AGI, 1980).

permeability, intrinsic, (L^2) -

(1) a measure of the relative ease with which a porous medium can transmit a fluid under a potential gradient and is a property of the medium alone (after Lohman and others, 1972).

(2) the property of a porous medium itself that expresses the ease with which gases, liquids, or other substances can pass through it (after SSSA, 1975).

permeability, relative -

(1) the ratio of the effective permeability for a given flow phase to the intrinsic permeability of the porous medium (WMO, 1974).

(2) the ratio of the effective and specific permeabilities (Thrush, 1968).

permeability, specific - the permeability measured when the rock contains only one fluid (Thrush, 1968).

phreatic line - see seepage line.

phreatic surface - see water table.

piezometer - a devise used to measure ground-water pressure head at a point in the subsurface.

piezometric surface - see potentiometric surface.

point source -

(1) any discernable, confined, or discrete conveyance from which pollutants are or may be discharged, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft (APHA, 1981).

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(2) Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture [Public Law 95-217, SEC. 502 (14) as amended by Public Law 100-4, SEC. 503].

pollutant or contaminant -

(1) see contaminant.

(2) shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring; except that the term "pollutant or contaminant" shall not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of paragraph (14) (CERCLA) and shall not include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas) [Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) (Public Law 96-510) as amended by Superfund Admendments and Reauthorization Act of 1986 (Public Law 99-499)].

pollution -

(1) specific impairment of water quality by agricultural, domestic, or industrial wastes (including thermal and atomic wastes), to a degree that has an adverse effect upon any beneficial use of water.

(2) the addition to a stored body of water of any material which diminishes the optimal economic use of the water body by the population which it serves, and has an adverse effect on the surrounding environment (APHA, 1981).

pore - see interstice.

pore space - the total space not occupied by solid soil or rock particles (SSSA, 1975).

pore velocity - see velocity, average interstitial.

porosity, (D) -

> (1) the ratio, usually expressed as a percentage, of the total volume of voids of a given porous medium to the total volume of the porous medium (after ASTM, 1980).

> (2) the volume percentage of the total bulk not occupied by solid particles (SSSA, 1975).

porosity, effective, (D) -

> (1) the ratio, usually expressed as a percentage of the total volume of voids available for fluid transmission to the total volume of the porous medium.

> (2) the ratio of the volume of the voids of a soil or rock mass that can be drained by gravity to the total volume of the mass (ASTM, 1980).

> (3) the amount of interconnected pore space and fracture openings available for the transmission of fluids, expressed as the ratio of the volume of interconnected pores and openings to the volume of rock (10 CFR Part 960.2).

potable water - water that is suitable for human consumption.

potential - any of several different scalar quantities, each of which involves energy as a function of position or of condition; e.g. the fluid potential of ground water (AGI, 1980).

potential density -

> (1) the density of a unit of water after it is raised by an adiabatic process to the surface, i.e., determined from in-situ salinity and potential temperature (AGI, 1980).

> (2) density that would be reached by a compressible fluid if it were adiabatically compressed or expanded to a standard pressure (McGraw-Hill, 1974).

potential drop, (L) - the difference in total head between two equipotential lines (ASTM, 1980).

potentiometric surface - an imaginary surface representing the static head of ground water and defined by the level to which water will rise in a tightly cased well (after Lohman and others, 1972).

pressure head - hydrostatic pressure expressed as the height of a column of water that the pressure can support at the point of measurement. See also head, static, and pressure, hydrostatic.

pressure, hydrostatic, $(M \, L^{-1} \, T^{-2})$ - the pressure exerted by the weight of water at any given point in a body of water at rest (after AGI, 1972).

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radioisotope - an unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation (NRC, 1981).

radionuclide - a radioisotope (NRC, 1981).

radionuclide retardation - the process or processes that cause the time required for a given radionuclide to move between two locations to be greater than the ground water travel time, because of physical and chemical interactions between the radionuclide and the geohydrologic unit through which the radionuclide travels (10 CFR Part 960.2).

reaction path modeling - a simulation approach to studying the chemical evolution of a (natural) system.

recharge - the process of addition of water to the saturated zone; also the water added (USGS, 1984).

recharge area - an area in which water reaches the zone of saturation by surface infiltration (Heath, 1984).

recharge capacity - the ability of the soils and underlying materials to allow precipitation and runoff to infiltrate and reach the zone of saturation (30 CFR Parts 701.5 and 710.5).

retardation factor - the ratio of the average linear velocity of ground water to the velocity of the retarded constituent at $C/C_0 = 0.5$ (after Freeze and Cherry, 1979).

saline water - water that generally is considered unsuitable for human consumption or for irrigation because of its high content of dissolved solids. Commonly expressed as milligrams per liter (mg/L) of dissolved solids, with 35,000 mg/L defined as equivalent to sea water, slightly saline as 1,000 - 3,000 mg/L, moderately saline as 3,000 - 10,000 mg/L, very saline as 10,000 - 35,000 mg/L, and brine has more than 35,000 mg/L (after USGS, 1984).

saltwater intrusion - the movement of salt water into fresh water aquifers (ASCE, 1985).

saturated zone -

(1) those parts of the earth's crust in which all voids are filled with water under pressure greater than atmospheric (Lohman and others, 1972).

(2) that part of the earth's crust beneath the regional water table in which all voids, large and small, are filled with water under pressure greater than atmospheric (after NRC, 1985).

(3) means that part of the earth's crust beneath the regional water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric (10 CFR Part 60.2).

(4) means that part of the earth's crust beneath the water table in which all voids, large or small, are ideally filled with water under pressure greater than atmospheric (10 CFR Part 960.2).

seep -

(1) an area, generally small, where water or oil percolates slowly to the land surface (see seepage and spring) (AGI, 1980).

(2) to move slowly through small openings of a porous material (AGI, 1980).

seepage -

(1) the fluid discharged at a seep.

(2) the amount of fluid discharged at a seep.

seepage face - a boundary between the saturated flow field and the atmosphere along which ground water discharges, either by evaporation or movement "downhill" along the land surface or in a well as a thin film in response to the force of gravity (after Franke and others, 1985).

seepage line -

(1) the uppermost level at which flowing water emerges along a seepage face (AGI, 1980).

(2) the upper free water surface of the zone of seepage (ASTM, 1980). Synonymous with line of seepage, phreatic line.

seepage velocity - see specific discharge.

semiconfined aquifer - see leaky aquifer.

site characterization -

(1) a general term applied to the investigation activities at a specific location that examines natural phenomena and human-induced conditions important to the resolution of environmental, safety and water-resource issues.

(2) means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the program. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken (10 CFR Part 960.2).

(3) activities, whether in the laboratory or the field, undertaken to
     establish the geologic conditions and the ranges of the parameters
     of a candidate site relevant to the location of a repository,
     including borings, surface excavations, excavation of exploratory
     shafts, limited surface lateral excavations and borings, and in situ
     testing needed to evaluate the suitability of a candidate site for
     the location of a repository, but not including preliminary borings
     and geophysical testing needed to assess whether site
     characterization should be undertaken (10 CFR Part 960.2).

soil bulk density - the mass of dry soil per unit bulk soil (SSSA, 1975).

soil moisture, (D) - subsurface liquid water in the unsaturated zone expressed
     as a fraction of the total porous medium volume occupied by water. It is
     less than or equal to the porosity, n (NRC, 1985).

soil water - see soil moisture.

soil-water pressure - the pressure (positive or negative), in relation to the
     external gas pressure on the soil water, to which a solution identical in
     composition with the soil water must be subjected in order to be in
     equilibrium through a porous permeable wall with the soil water (SSSA,
     1975).

solubility - the total amount of solute species that will remain indefinitely
     in a solution maintained at constant temperature and pressure in contact
     with the solid crystals from which the solutes were derived.

solute - the substance present in a solution in the smaller amount. For
     convenience, water is generally considered the solvent even in
     "concentrated" solutions with water molecules in the minority.

solute transport - the net flux of solute through a hydrogeologic unit
     controlled by the flow of subsurface water and transport mechanisms.

solution - a homogeneous mixture of two or more components. In ideal
     solutions, the movement of molecules in charged species are independent
     of each other. In aqueous solutions charged species interact even at
     very low concentrations, decreasing the activity of the solutes.

sorption -

     (1) a general term used to encompass the process of absorption and
          adsorption.

     (2) all processes which remove solutes from the fluid phase and concen-
          trate them on the solid phase of the medium (after ANS, 1980).

source term - the kinds and amounts of radionuclides that make up the source
     of a potential release of radioactivity (10 CFR Part 960.2).

specific capacity, $(L^2 T^{-1})$ - the rate of discharge of water from the well divided by the drawdown of the water level within the well (Lohman and others, 1972).

specific conductance - a measure of the ability of water to conduct an electrical current expressed in micromhos per centimeter at 25°C (ASCE, 1985).

specific discharge, (LT^{-1}) - the rate of discharge of ground water per unit area of a porous medium measured at right angle to the direction of flow (Lohman and others, 1972).
     Synonymous with flow velocity or specific flux.

specific retention, (D) - the ratio of the volume of water which the porous medium, after being saturated, will retain against the pull of gravity to the volume of the porous medium (Lohman and others, 1972).

specific storage, (L^{-1}) - the volume of water released from or taken into storage per unit volume of the porous medium per unit change in head (Lohman and others, 1972).

specific yield, (D) - the ratio of the volume of water which the porous medium after being saturated, will yield by gravity to the volume of the porous medium (Lohman and others, 1972).

spring - a discrete place where ground water flows naturally from a rock or the soil onto the land surface or into a body of surface water (ASCE, 1985).
     See also seep.

static head - see head, static.

storage coefficient, (D) - the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (virtually equal to the specific yield in an unconfined aquifer) (Lohman and others, 1972).

storativity - see storage coefficient.

subsurface water - all water that occurs below the land surface.

subirrigation -

(1) irrigation of plants with water delivered to the roots from underneath (30 CFR Part 710.b).

(2) with respect to alluvial valley floors, the supplying of water to plants from underneath or from a semisaturated or saturated subsurface zone where water is available for use by vegetation (30 CFR Part 701.5).

suction - see moisture tension.

tensiometer - a device used to measure the moisture tension in the unsaturated zone.

total dissolved solids -

(1) the total concentration of dissolved constituents in solution, usually expressed in milligrams per liter.

(2) the total concentration of dissolved material in water [as] ordinarily determined from the weight of the dry residue remaining after evaporation of the volatile portion of an aliquot of the water sample (Hem, 1985).

(3) the total dissolved (filterable) solids as determined by use of the method specified in 40 CFR Part 136 (40 CFR 144.3; 40 CFR 146.3).

total hydraulic head - see head, total.

total soil-water potential - the sum of the energy-related components of a soil-water system; i.e., the sum of the gravitational, matric, and osmotic components (Wilson, 1980).

transient -

(1) a pulse dampered oscillation or other temporary phenomena occuring in a system prior to reaching a steady-state condition (McGraw-Hill, 1974).

(2) see flow, unsteady.

transmissibility coefficient - (The use of the term transmissibility has been replaced by transmissivity).

transmissivity, ($L^2 T^{-1}$) - the rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths (Lohman and others, 1972).

transport - conveyance of solutes and particulates in flow systems.
    See also solute transport and particulate transport.

turbulent flow - the flow condition in which inertial forces predominate over viscous forces and in which head loss is not linearly related to velocity.

unconfined - a condition in which the upper surface of the zone of saturation forms a water table under atmospheric pressure (after ASCE, 1985).

unconfined aquifer - an aquifer which has a water table.

underground injection - a "well injection" (40 CFR 144.3; 40 CFR Part 146.3).

unsaturated flow - the movement of water in a porous medium in which the pore spaces are not filled to capacity with water (after SSSA, 1975).

unsaturated zone -

(1) the zone between the land surface and the water table (ASCE, 1985).

(2) the zone between the land surface and the deepest water table which includes the capillary fringe. Water in this zone is generally under less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the water pressure locally may be greater than atmospheric (Lohman and others, 1972).

(3) the zone between the land surface and the regional water table. Generally, water in this zone is under less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the water pressure locally may be greater than atmospheric (NRC, 1985).

(4) means the zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the fluid pressure locally may be greater than atmospheric (10 CFR Part 60.2).

(5) the zone between the land surface and the water table. Generally, water in this zone is under less than atmospheric pressure, and some of the voids may contain air and other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies, the water pressure locally may be greater than atmospheric (10 CFR Part 960.2).

upconing - process by which saline water underlying freshwater in an aquifer rises upward into the freshwater zone as a result of pumping water from the freshwater zone (USGS, 1984).

vadose zone - see unsaturated zone.

velocity, average interstitial, (LT^{-1}) - the average rate of ground-water flow in interstices expressed as the product of hydraulic conductivity and hydraulic gradient divided by the effective porosity, (after Lohman and others, 1972).
   Synonymous with average linear ground-water velocity or effective velocity.

void - see interstice.

void ratio, (D) - the ratio of (a) the volume of void space to (b) the volume
f solid particles in a given soil mass (ASTM, 1980).

volatiles - substances with relatively large vapor pressures. Many organic
substances are almost insoluble in water so that they occur primarily in
a gas phase in contact with water, even though their vapor pressure may
be very small.

water content - the amount of water lost from the soil after drying it to
constant weight at 105°C, expressed either as the weight of water per
unit weight of dry soil or as the volume of water per unit bulk volume of
soil (ASTM, 1980).
See also moisture content.

water-holding capacity - see specific retention.

water table -

(1) the upper surface of a zone of saturation except where that surface
is formed by a confining unit (after Lohman, 1972).

(2) the upper surface of the zone of saturation on which the water
pressure in the porous medium equals atmospheric pressure.

(3) means that surface in a ground-water body at which the water
pressure is atmospheric (10 CFR Part 60.2).

(4) that surface in a body of ground water at which the water pressure
is atmospheric (10 CFR Part 960.2).

(5) upper surface of a zone of saturation, where the body of ground
water is not confined by an overlying impermeable zone (30 CFR Part
701.5 and 710.5).

water-table aquifer - see unconfined aquifer.

well - a bored, drilled or driven shaft, or a dug hole, whose depth is greater
than the largest surface dimension (40 CFR 144.3 and 40 CFR 146.3).

well injection - the subsurface emplacement of "fluids" through a bored,
drilled, or driven "well", or through a dug well, where the depth of the
dug well is greater than the largest surface dimension (40 CFR 144.3 and
40 CFR 146.3).

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Table 1. List of Parameters, Their Symbols and Units

Parameter	Symbol	Dimension	SI Units	English Units
air space ratio	G_a	(Dimensionless)	---	---
average interstitial velocity	$\bar{v}_i$	LT^{-1}	m/s	ft/day
capillary head, capillary rise	h_c	L	cm	in
cation exchange capacity	CEC	charge M^{-1}	(mol(+)/kg)*	---
centrifuge moisture equivalent	w_c	---	---	---
coefficient of hydro-dynamic dispersion	(see dispersion coefficient)			
coefficient of mechanical diffusion	D_m	L^2T^{-1}	m^2/s	ft^2/s
coefficient of molecular diffusion	D*	L^2T^{-1}	m^2/s	ft^2/s
coefficient of permeability	(see permeability)			
conductivity, effective hydraulic	$\bar{\bar{K}}_e$	LT^{-1}	m/s	ft/day
conductivity, hydraulic	$\bar{\bar{K}}$	LT^{-1}	m/s	ft/day
dispersion coefficient	$D\alpha$	L^2T^{-1}	m^2/s	ft^2/s
diffusivity, soil water	D	L^2T^{-1}	m^2/s	ft^2/s
dispersivity	α	L	m	ft
discharge velocity	(see specific discharge)			
distribution coefficient	Kd	L^3M^{-1}	m^3/kg	ft^3/lb
drawdown	s	L	m	ft

Table 1. List of Parameters, Their Symbols and Units (continued)

Parameter	Symbol	Dimension	SI Units	English Units
effective hydraulic conductivity (see conductivity, effective hydraulic)				
exchange capacity	EC	charge M^{-1}	(mol(+)/kg)	---
effective porosity	n_e	---	---	---
fluid potential	$\emptyset$	L^2T^{-2}	m^2/s^2	ft^2/s^2
flux	(see specific discharge)			
gravitational head	Hg	L	m	ft
ground-water flow (total discharge, or total flux)	Q	L^3T^{-1}	m^3/s	gal/day ft^3/day
head, elevation	h_e	L	m	ft
head, pressure	h_p	L	m	ft
head, static	h	L	m	ft
head, total	H	L	m	ft
hydraulic conductivity	(see conductivity, hydraulic)			
hydraulic diffusivity	T/S or K/S_s	L^2T^{-1}	m^2/s	ft^2/day
hydraulic gradient	I	---	---	---
hydraulic head	H	L	m	ft
matric potential	Ψ_m	L	m	in
moisture content (moisture equivalent)	w	---	---	---
permeability	$\bar{\bar{k}}$	LT^{-1}	m/s	ft/day
permeability, intrinsic	$\bar{\bar{k}}_i$	L^2	m^2	ft^2
pore velocity	(see average interstitial velocity)			
porosity	n	---	---	---

Table 1. List of Parameters, Their Symbols and Units (continued)

Parameter	Symbol	Dimension	SI Units	English Units
porosity, effective	n_e	---	---	---
potential drop	Δh	L	m	ft
pressure head	(see head, pressure)			
pressure, static	p	$ML^{-1}T^{-2}$	N/m^2	lb/in^2
seepage velocity	(see specific discharge)			
specific capacity	C_s	L^2T^{-1}	m^2/s	gal/min/ft ft^3/min/ft
specific discharge (specific flux)	q	LT^{-1}	m/s	ft/s
specific retention	S_r	---	---	---
specific storage	S_s	L^{-1}	m^{-1}	ft^{-1}
specific yield	Sy	---	---	---
storage coefficient	S	---	---	---
stress, neutral (pore pressure, pore water pressure)	u_w	$ML^{-1}T^{-2}$	N/m^2	lb/ft^2
Transmissivity	T	L^2T^{-1}	m^2/s	ft^2/day
velocity, average interstitial	$\bar{v}_i$	LT^{-1}	m/s	ft/day
void ratio	e	---	---	---

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* standard units used.

Table 2. Pressure Conversion factors.[a] (After Johnson, 1981)

Taken or calculated (*) from Zimmerman, O.T., and Lavine, Irvin, 1955,
Conversion factors and tables: Industrial Research Service, Inc., Dover, NH

	atm	cm, Mercury	mm, Mercury	in., Mercury	cm, Water	mm, Water	in., Water	ft., Water	psi	Bars[b]
atm	1	76 (0°C)	760 (0°C)	29.921 (32°F)	1033.2487* (39.2°F)	10332.4867* (39.2°F)	406.79 (39.2°F)	33.899 (39.2°F)	14.6960	1.013250
cm, mercury, 0°C	0.0131579	1	10* 0°C	0.3937 (0°C)	13.5956* (32°F)	135.9563* (39.2°F)	5.3526* (39.2°F)	0.44605 (39.2°F)	0.193368 (39.2°F)	0.01333221
mm, mercury 0°C	0.001315789	0.1* (0°C)	1	0.03937 (0°C)	1.3596* (39.2°F)	13.5956* (39.2°F)	0.5353* (39.2°F)	0.044604 (39.2°F)	0.0193368	0.001333223
in., mercury 32°F	0.0334211	2.54000508*	25.4000508 (0°C)	1	34.5376* (39.2°F)	345.3765* (39.2°F)	13.596* (39.2°F)	1.1330 (39.2°F)	0.491157	0.0338640
cm, water, 39.2°F	0.00096779*	0.07355* (32°F)	0.73553* (32°F)	0.028958* (32°F)	1	10* (39.2°F)	0.3937* (39.2°F)	0.03281* (39.2°F)	0.014223*	0.000980616*
mm, water, 39.2°F	0.00009678* (32°F)	0.007355* (32°F)	0.07355* (32°F)	0.0028963* (32°F)	0.1* (39.2°F)	1	0.03937* (39.2°F)	0.003281 (39.2°F)	0.001422*	0.000098062*
in., water, 39.2°F	0.0024582	0.18683* (32°F)	1.86828* (32°F)	0.073554 (32°F)	2.54000508* (39.2°F)	25.4000508* (39.2°F)	1	0.0833333* (39.2°F)	0.0361265	0.00249077*
ft, water, 39.2°F	0.0294990	2.24193 (0°C)	22.4193* (0°C)	0.882647 (32°F)	30.48006096* (39.2°F)	304.8006096* (39.2°F)	12* (39.2°F)	1	0.433518	0.0298899*
psi	0.0680457	5.17148 (0°C)	51.7148	2.03601 (32°F)	70.3099* (39.2°F)	703.0988* (39.2°F)	27.681 (39.2°F)	2.3067 (39.2°F)	1	0.0689473
Bars	0.9869233	75.0062 (0°C)	750.062 (0°C)	29.530 (32°F)	1020.6858* (39.2°F)	10206.858* (39.2°F)	401.844* (39.2°F)	33.487 (60°F)	14.50385	1

[a]Multiply the unit at the left by the number in the column to get the unit at the top of the column (from Johnson and others, 1961).

[b]The Pascal (Pa) is the accepted SI unit for pressure. The conversion values for Pa would be 1×10^5 larger for those listed under Bars; the conversion values for dyne cm^{-2} would be 1×10^6 larger for those listed under Bars.

Table 3. Permeability conversion factors.[a] (After Johnson, 1981)

	m per s	ft per Day	ft per Year	Darcy	Meinzer, gallons per day per ft^2
m per s	1	2.835×10^5	1.0348×10^8	1.033×10^5	2.12×10^6
ft per day	3.53×10^{-6}	1	365	3.64×10^{-1}	7.48
ft per year	9.67×10^{-9}	2.74×10^{-3}	1	9.99×10^{-4}	2.05×10^{-2}
Darcy	9.68×10^{-6}	2.75	1.001×10^3	1	20.50
Meinzer, gallons per day per ft^2	4.72×10^{-7}	1.34×10^{-1}	48.8	4.88×10^{-2}	1

[a]Multiply the unit at the left by the number in the column to get the unit at the top of the column. All units are based on temperature of 60°F or 15.6°C (from Johnson, 1963).

Table 4. Conversion factors for hydraulic units of measure (After Lohman and others, 1972)
[Equivalent values shown in same horizontal lines]

	Cubic feet per second ($ft^3 \ sec^{-1}$)	Acre-feet per day (ac-ft day^{-1})	Acre-feet per year (ac-ft yr^{-1})	Gallons per minute (gal min^{-1})	Gallons per day (gal day^{-1})	Cubic feet per day ($ft^3 day^{-1}$)	Cubic meters per day ($m^3 day^{-1}$)	Square mile-inch per year (mi^2-in yr^{-1})
Cubic feet per second ($ft^3 \ sec^{-1}$)	One	1.9835	7.2397×10^2	4.4883×10^2	6.4632×10^5	8.6400×10^4	2.4466×10^3	1.3574×10^1
Acre-feet per day (ac-ft day^{-1})	5.0417×10^{-1}	One	3.6500×10^2	2.2629×10^2	3.2585×10^5	4.3560×10^4	1.2335×10^3	6.8438
Acre-feet per year (ac-ft yr^{-1})	1.3813×10^{-3}	2.7397×10^{-3}	One	6.1996×10^{-1}	8.9274×10^2	1.1934×10^2	3.3794	1.8750×10^{-2}
Gallons per minute (gal min^{-1})	2.2280×10^{-3}	4.4192×10^{-3}	1.6130	One	1.4400×10^3	1.9250×10^2	5.4510	3.0244×10^{-2}
Gallons per day (gal day^{-1})	1.5472×10^{-6}	3.0689×10^{-6}	1.1201×10^{-3}	6.9444×10^{-4}	One	1.3368×10^{-1}	3.7854×10^{-3}	2.1003×10^{-5}
Cubic feet per day ($ft^3 day^{-1}$)	1.1574×10^{-5}	2.2957×10^{-5}	8.3793×10^{-3}	5.1948×10^{-3}	7.4805	One	2.8317×10^{-2}	1.5711×10^{-4}
Cubic meters per day ($m^3 day^{-1}$)	4.0873×10^{-4}	8.1071×10^{-4}	2.9591×10^{-1}	1.8345×10^{-1}	2.6417×10^2	3.5314×10^1	One	5.5483×10^{-3}
Square mile-inch per year (mi^2-in yr^{-1})	7.3668×10^{-2}	1.4612×10^{-1}	5.3333×10^1	3.3065×10^1	4.7613×10^4	6.3649×10^3	1.8024×10^2	One

Table 5. Relation of units (From Lohman and others, 1972).
[Equivalent values shown in same horizontal lines. ‡Indicates abandoned term]

A. Hydraulic conductivity

Hydraulic conductivity (K)		‡Field coefficient of permeability (P_f)
Feet per day (ft day^{-1})	Meters per day (m day^{-1})	‡Gallons per day per square foot (gal day^{-1} ft^{-2})
One	0.305	7.48
3.28	One	24.5
.134	0.041	One

B. Transmissivity

Square feet per day (ft^2 day^{-1})	Square meters per day (m^2 day^{-1})	‡Gallons per day per foot (gal day^{-1} ft^{-1})
One	0.0929	7.48
10.76	One	80.5
0.134	0.0124	One

C. Permeability

Intrinsic permeability		‡Coefficient of permeability
$k = \dfrac{-qv}{d\phi/dl}$	$Darcy = \dfrac{-q\mu}{dp/dl + \rho g\, dz/dl}$	$P \text{ or } P_m = \dfrac{-q(\text{at } 60°F)}{dh/dl}$
$[(\mu m)^2 = 10^{-8}\ cm^2]$	$[0.987 \times 10^{-8}\ cm^2]$	[gal day^{-1} ft^{-2} at 60°F]
One	1.01	18.4
0.987	One	18.2
0.054	0.055	One